Motor Control Application Kit

KIT_XMC750WATT_AK_V1

XMC 750 Watt Motor Control Application Kit
3-Phase drives evaluation with galvanic isolation

Board User's Manual

Revision 1.0, 2014-01-30

Microcontroller

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Revision History	
Page or Item	**Subjects (major changes since previous revision)**
Revision 1.0, 2014-01-30	Initial release

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Introduction

This document describes the features and hardware details of the “3 Phase Power Inverter 750W V1.1” which is designed to work with Infineon’s DriveCards. DriveCards are microcontroller boards with isolated debug interface best suited for motor control applications. This power board together with two drive cards (KIT_XMC1300_DC_V1 and KIT_XMC4400_DC_V1) is included in the XMC Motor Control Application Kit KIT_XMC750WATT_AK_V1.

1 Overview

The motor control application kit KIT_XMC750WATT_AK_V1 is designed for use with 230V AC mains power supply. The drive cards provide a galvanically isolated debug interface that allows safe software development. A PFC circuitry can be controlled by the on-board PFC IC or by the microcontroller at the drive card. The power inverter bridge is built by 6 discrete IGBTs in DPAK package. Each leg provides a shunt resistor with amplifier for phase current measurement. The DC-link also provides a shunt resistor with amplifier for reconstruction of the phase current with single shunt method. An additional low pass filter allows measuring the average DC-link current as well. The power supply for the control devices as well as the drive card is provided by a non isolated flyback converter which provides 5V and 15V DC. The auxiliary power board connector allows adding an inverter card in order to use the board together with the XMC4400 drive card as dual inverter.
The main use case for this board is to demonstrate the generic features of the XMC microcontroller devices including tool chain. The focus is the operation under evaluation conditions. The board is neither cost nor size optimized and does not serve as a reference design.
Software examples as well as DAVE Apps are available for download at www.infineon.com/xmc-dev.

1.1 Key Features

The XMC Motor Control Appkication Kit (KIT_XMC750WATT_AK_V1) provides the following features:

- 3 Phase Power Inverter 750W V1.1 (2013/45)
  - Power supply with line filter, NTC bypass relay and PFC circuitry
  - 3 phase bridge realized with discrete IGBTs (IKD10N60R)
  - Integrated gate driver with integrated boot strap diodes and protection features (6EDL04I06NT)
  - PFC control via control IC (ICE3PCS02), MCU or disabled
  - PFC overcurrent protection fully realized in hardware
  - On-board power supply for control components (15V and 5V) with flyback controller (ICE3B0356JG)
  - Voltage dividers for DC-link and inverter output voltage measurement (e.g. for motor back EMF detection)
  - Current sensing circuitry for
    - PFC
    - DC-link current (single shunt measurement)
    - Low side inverter leg currents (emitter shunt measurement)
  - Auxiliary power board connector for optional inverter card
- Drive Card XMC1300
  - XMC1302 (ARM® Cortex™-M0-based) Microcontroller, 200 kByte on-chip Flash, TSSOP38
  - 1 set of combined hall sensor and encoder interfaces
  - Potentiometer
  - Isolated Debug Interface
- Drive Card XMC4400
  - XMC4400 (ARM® Cortex™-M4-based) Microcontroller, 512 kByte on-chip Flash, LQFP100
  - 2 sets of combined hall sensor and encoder interfaces
  - Multi feedback interface connectors for connection of resolver circuitry, UART, SPI, I2C, USB, etc
  - Potentiometer
  - Isolated Debug Interface

1.2 Block Diagram

Figure 1 shows the functional block diagram of the KIT_XMC750WATT_AK_V1.

The drive cards have got the following building blocks:

- Power Board Connector
- 1 or 2 sets of position interface connectors (HALL, ENCODER)
- Encoder Enable signals via GPIOs
- User LEDs connected to GPIOs
- Variable resistor (POTI) connected to ADC
- Isolated On-board Debugger via Debug USB connector (Micro-USB) with UART channel
- Optional Infineon Debug interface connector for Drive Monitor USB Stick V2 (KIT_DRIVEMONI_USB_V2)

Note: Additional documentation is provided for the drive cards (Board User's Manual Drive Card XMC1300 and XMC4400).

The power board has got the following building blocks:

- EMC line filter
- PFC circuitry with over current protection, selectable with PFC IC control or MCU control
- 3phase bridge with IGBTs driver IC and shunts (DC-link single shunt as well as three low side shunts)
- Control IC power supply 15V/5V
- Drive card connector
- Auxiliary power board connector

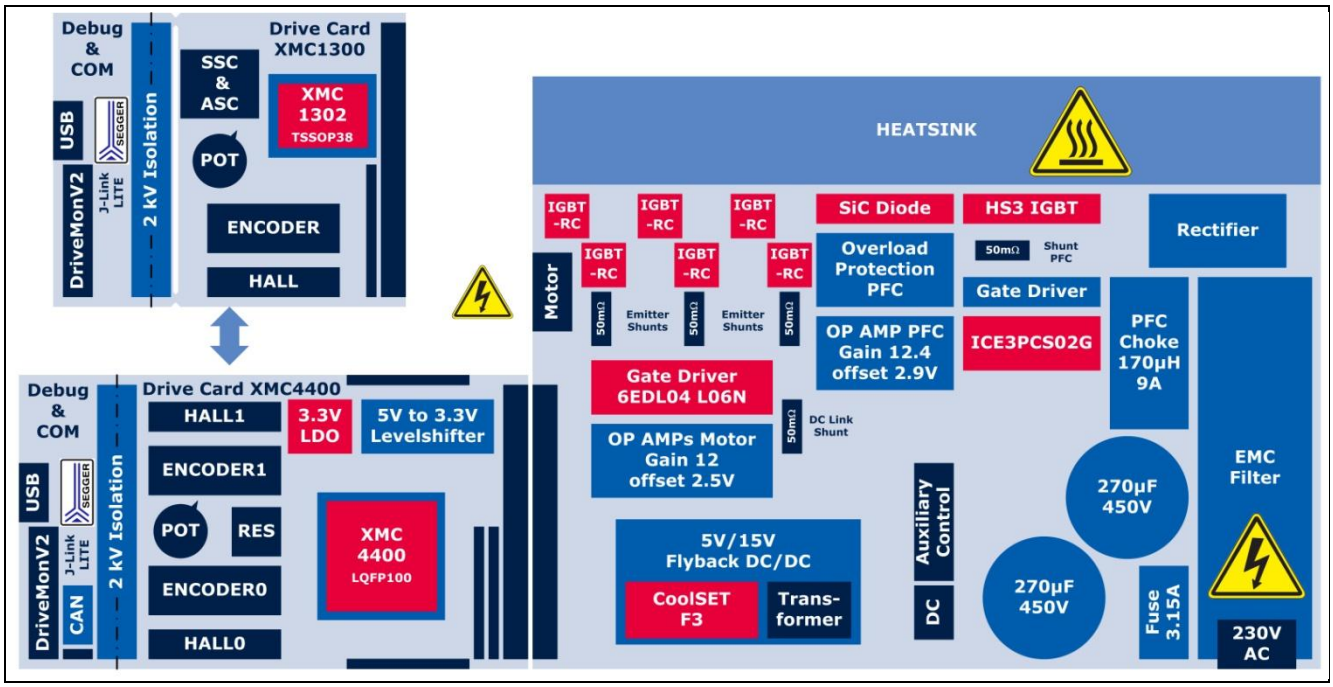


Figure 1 Block Diagram of KIT_XMC750WATT_AK_V1

Attention: Almost all signals of the kit including connectors and testpoints are referenced to power GND supply domain. Hence they may carry hazzardous voltages.

Attention: Due to large capacitors, the DC-Link voltage may provide hazzardous voltages even when the board is unplugged from power supply.

Attention: The heatsink and the power components including the PFC choke may get hot during operation.

2 Hardware Description

The following sections give a detailed description of the hardware and how it can be used.

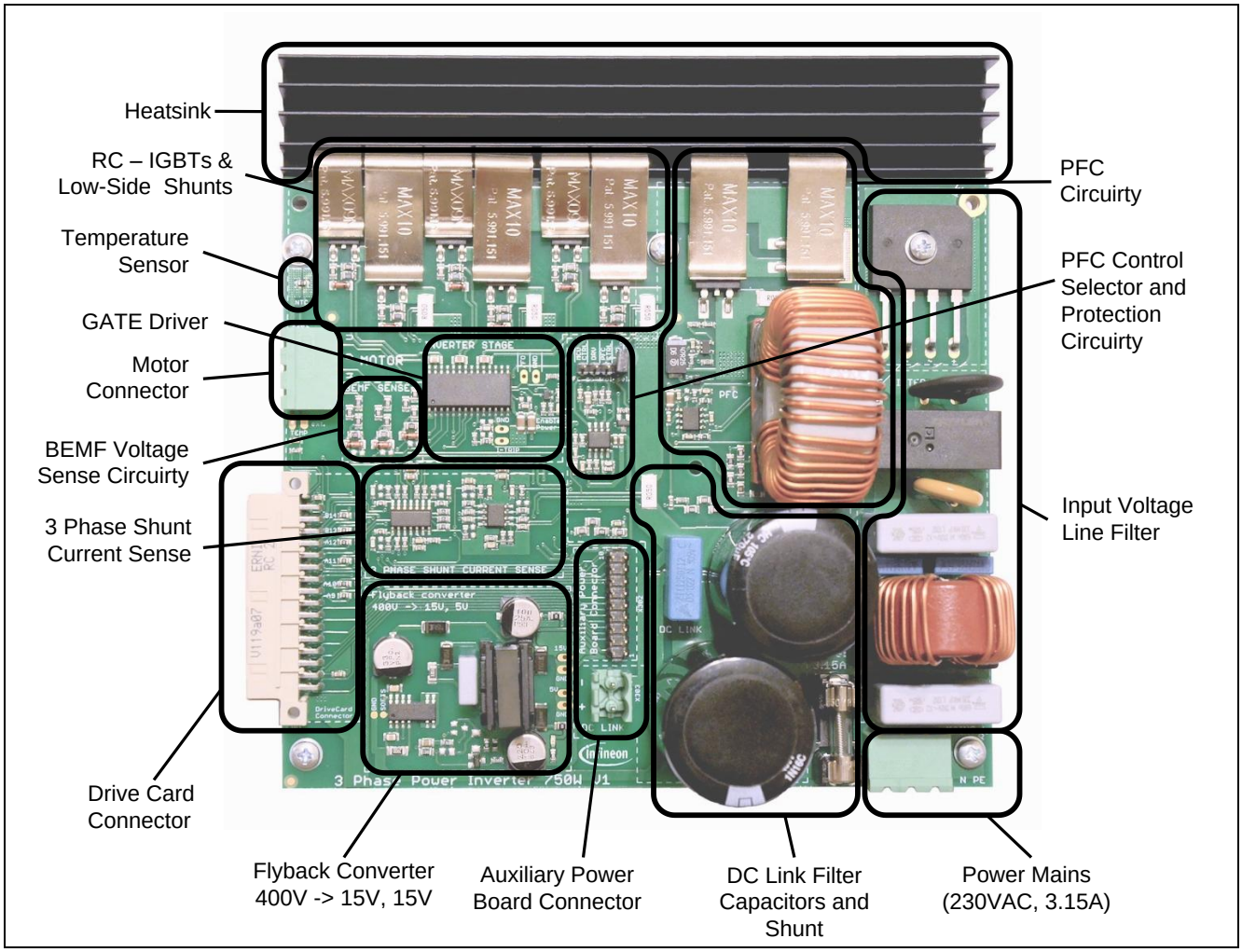


Figure 2 3 Phase Power Inverter 750W V1.1

Table 1 Maximum Ratings

Function	min	max	unit	comment
AC Input voltage without PFC	85	250	V AC	
AC input current	-	3.15	A AC	Limited by fuse F101
PFC input voltage	220	250	V AC	
PFC input current	-	3.5	A AC	Protected by PFC IC
DC-link voltage	120	450	V DC	
VCC_15V supply voltage	14	18	V	
VDD_5V supply voltage	4.65	5.35	V	
VDD_5V supply current	-	200	mA	
Inverter output continuous current	-4.16	4.16	A	
Inverter output peak current	-	9	A	Protected by gate driver IC

2.1 Power Supply

The the “3 Phase Power Inverter 750W V1.1” board is designed for use with 230V AC mains power supply. The power supply contains an EMC line filter with NTC bypass relay, an overcurrent protected PFC stage that can be controlled either by a PFC control IC or by the microcontroller and a flyback converter for 15V and 5V power supply.

2.1.1 EMC Line Filter

The input line filter design is shown in Figure 3. It is protected by a 3.15A fuse. The inrush current limiting NTC resistor R111 is by-passed by the relay K101 after a certain time. This reduces the power losses of the inverter.

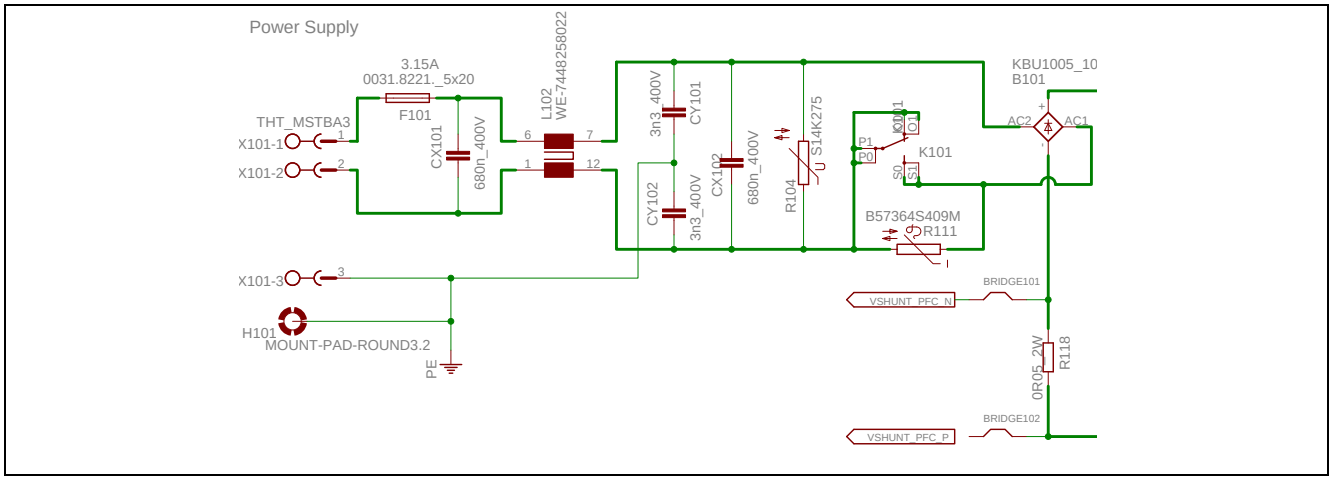


Figure 3 EMC Line Filter

The relay K101 is controlled by the circuitry of Figure 4.

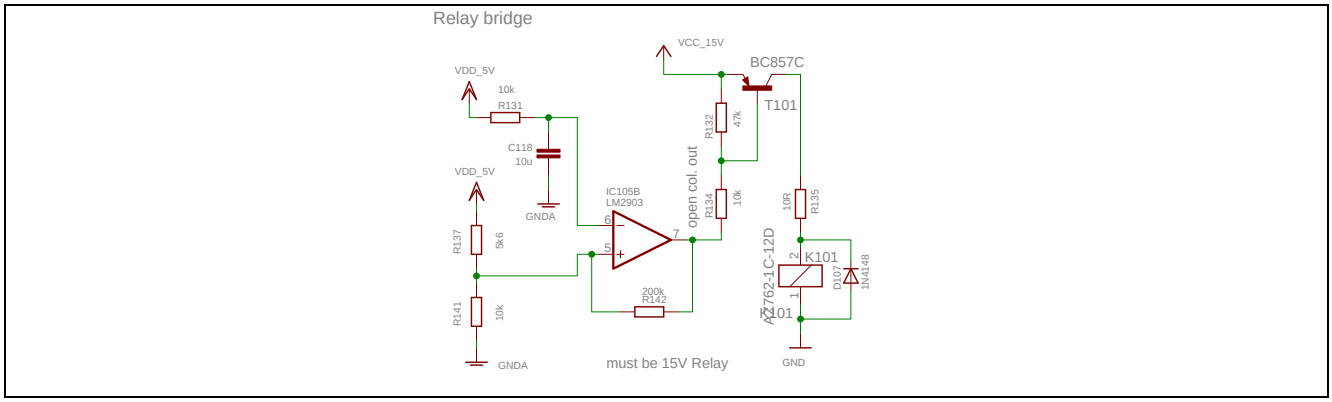


Figure 4 Control Circuitry of Relay K101

2.1.2 PFC Circuitry

The board provides a PFC circuitry which can be controlled by the on-board PFC control IC or by the microcontroller at the drive card. The PFC circuitry is designed to be controlled in continuous conduction mode for a boost voltage up to 400V DC. The maximum peak current is 4.72A. For details please refer to Figure 5 and Figure 6.

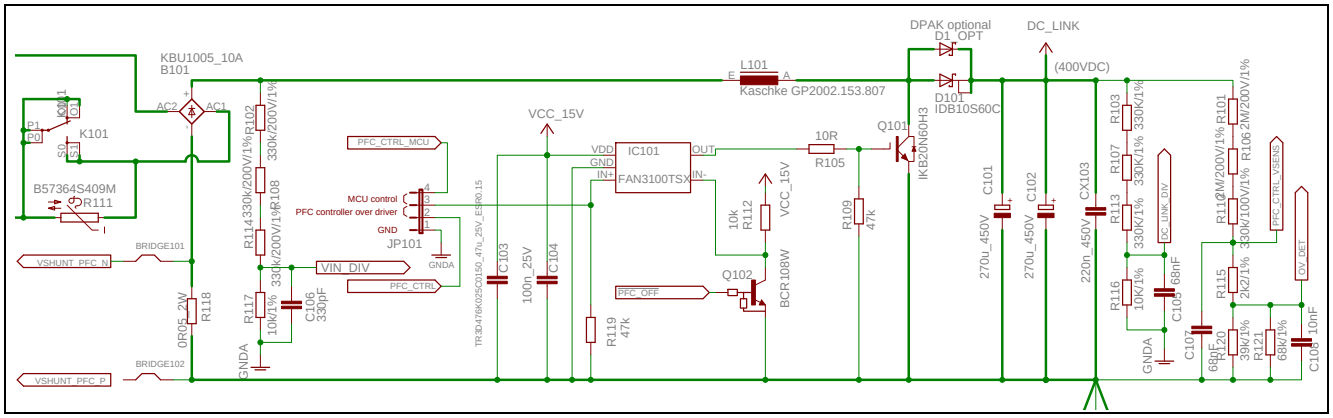


Figure 5 PFC Circuitry

The PFC control type selection is done with jumper JP101. Closed position 3-4 enables PFC control by MCU, closed position 2-3 enables control by the PFC IC. All pins of JP101 open, disables the PFC IC.

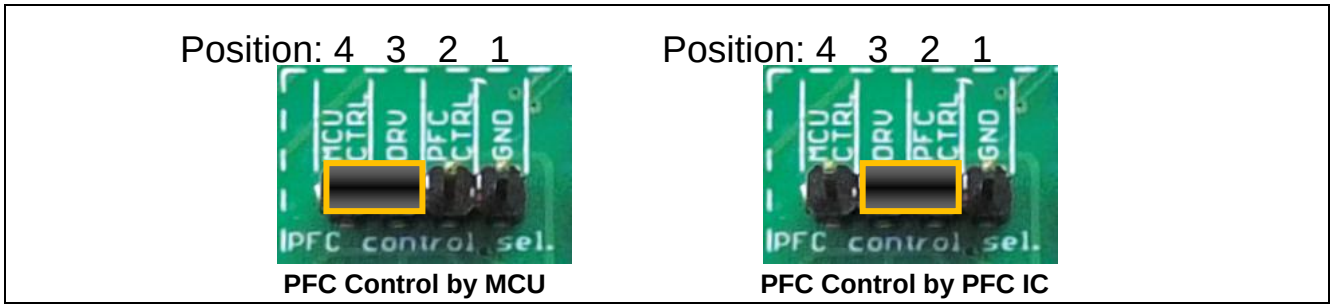


Figure 6 PFC Selector JP101

2.1.3 PFC Control IC, Current Sense and Over Current Protection

The PFC control IC (IC102) ICE3PCS02 is a wide input range (85VAC to 265VAC) controller IC for active CCM (continuous conduction mode) power factor correction. The integrated digital control voltage loop with a switching frequency of 66kHz allows efficieny up to 95% at full load for the entire input voltage range. See Figure 7 for details.

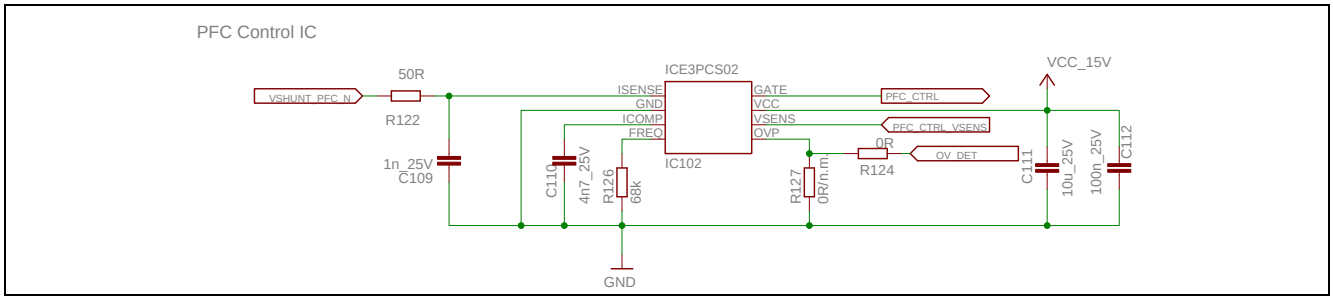


Figure 7 PFC Control IC ICE3PCS02

The PFC stage can be also controlled by the microcontroller of the drive card. There is a current sense amplifier with a gain of 12.4 available. As a result, the current sense signal from the 50mOhm shunt is amplified with a fully differential circuitry. An offset of 2.9V allows a current measurement in the range of –3.36A to +4.72A. The

over current protection is realized by a comparator (IC105A) which disables the gate driver (IC101, Figure 5) in case of overcurrent. Please refer to Figure 8 for details.

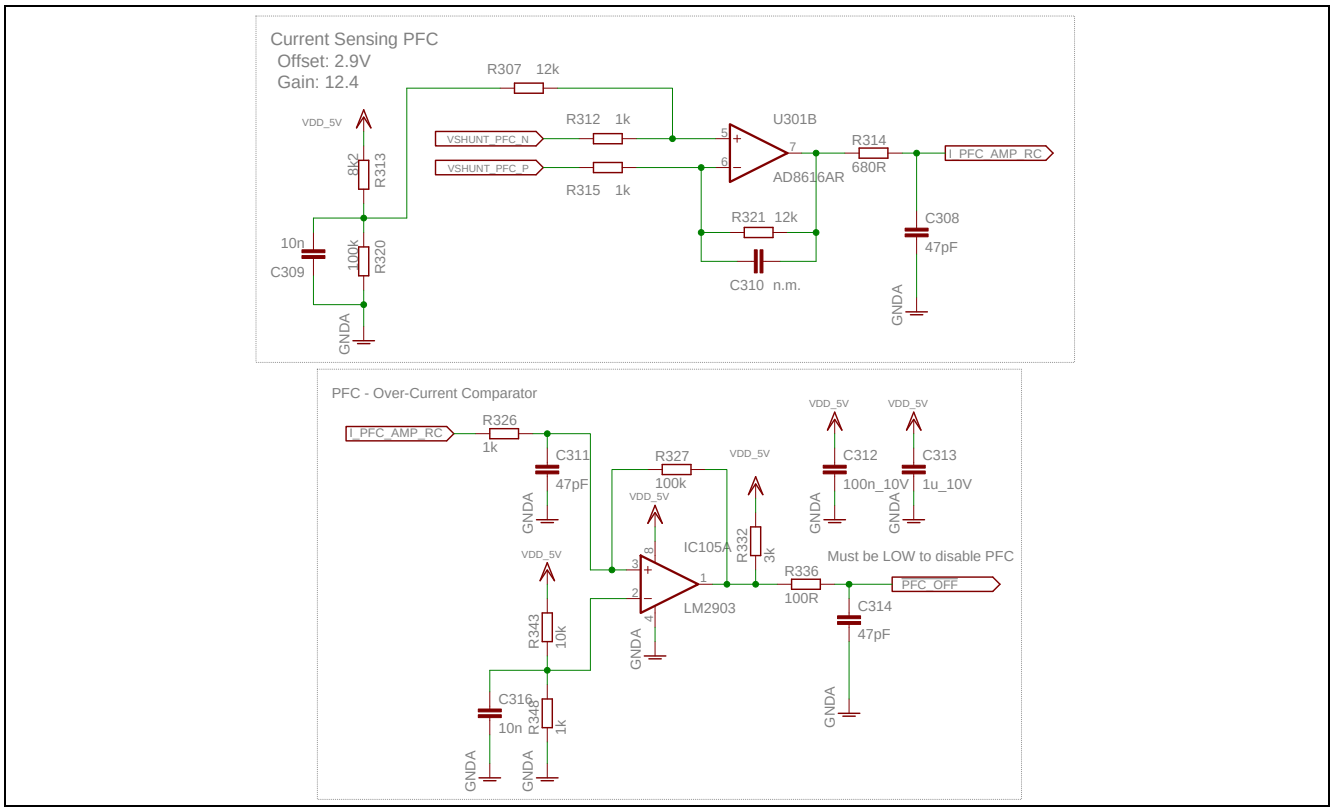


Figure 8 PFC Current Sense and Over Current Protection

The PFC current sense gain and offset can be calculated with following formulas:

$$\text{offset} = \frac{\frac{R315+R321}{R315}\cdot R312\cdot R320}{(R307+R312)\cdot R313+(R307+R312+R313)\cdot R320}\cdot \text{VDD\_5V}$$

$$\text{gain} = \frac{\frac{R315+R321}{R315}\cdot[(R307+R313)\cdot R320+R307\cdot R313]}{(R307+R312)\cdot R313+(R307+R312+R313)\cdot R320}$$

$$\text{Vout} = \text{offset} + \text{gain}\cdot\Delta\text{Vshunt} = \text{offset} - \text{gain}\cdot R118\cdot I_{PFC}$$

The over current protection threshold can be adjusted with R313; refer to Figure 9. Please note that gain and offset values also change with different R313.

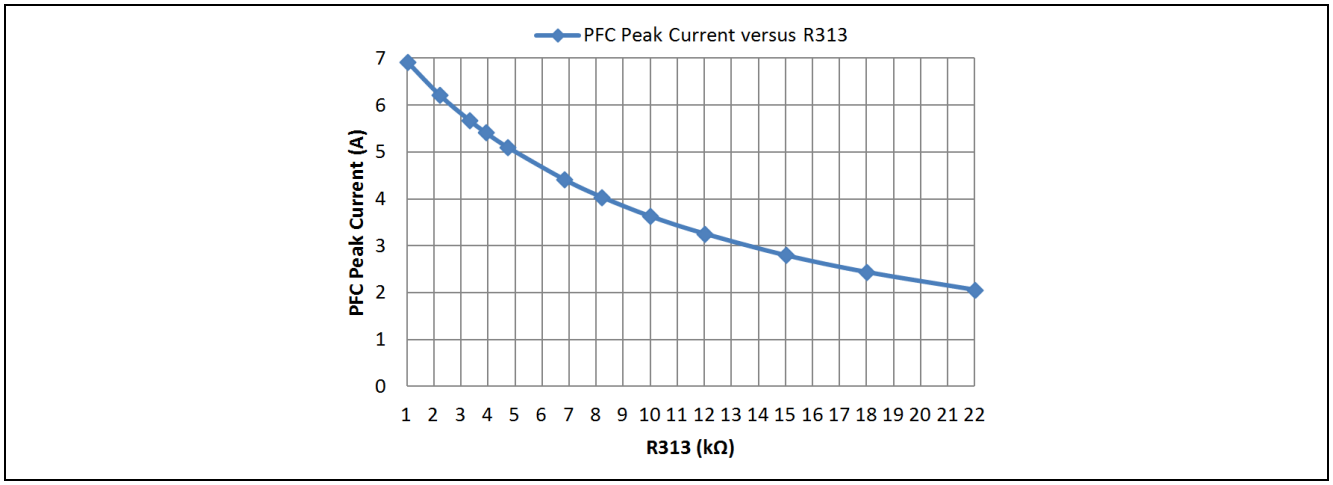


Figure 9 PFC Peak Current versus R313

2.1.4 Control Power Supply (VCC_15V and VDD_5V)

The control power supply with VCC_15V and VDD_5V is provided by a flyback switch mode power supply IC (IC103) ICE3B0356JG. The voltages can be monitored at test pins JP102 and JP103. The flyback control circuitry is shown in Figure 10. Please refer to Figure 28 for winding rules of transformer TR101.

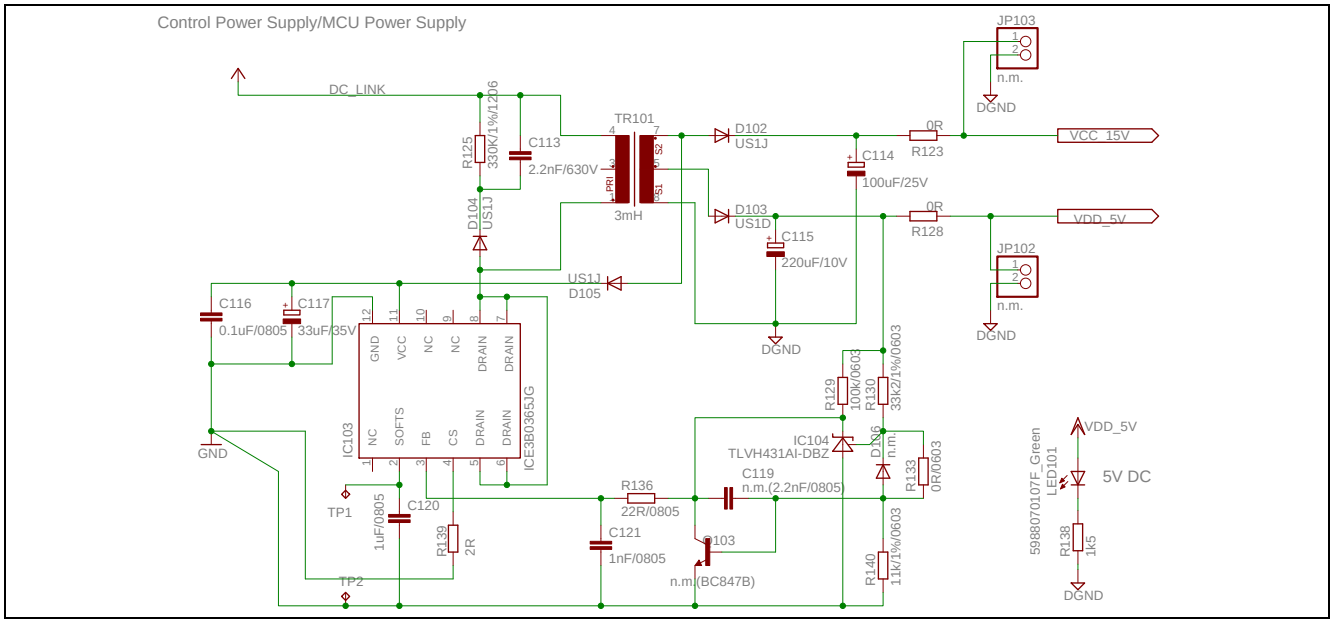


Figure 10 Control Power Supply (VCC_15V and VDD_5V)

There are two mounting options available for the feedback signal of the control loop: a) Using a shunt regulator (e.g. TLVH431AI) or b) using a zener diode. The following components are recommended for each option:

a) IC104 (TLVH431AI), R129 (100k), R130 (33.2k), R133 (0R), R140 (11.1k)

b) Q103 (BC847B), D106 (Zener diode 4.7V), C119 (2.2nF), R130 (4.3k), R140 (1k)

An external power supply for 5V as well as 15V can be used if required. Then R123 and R128 should be unmouned and the voltages can be applied at JP102 (5V) and JP103 (15V).

For test purposes it may make sense to restart the power supply. This can be achieved by connecting TP1 (SOFTS) and TP2 (GND). Please refer to 13 for details.

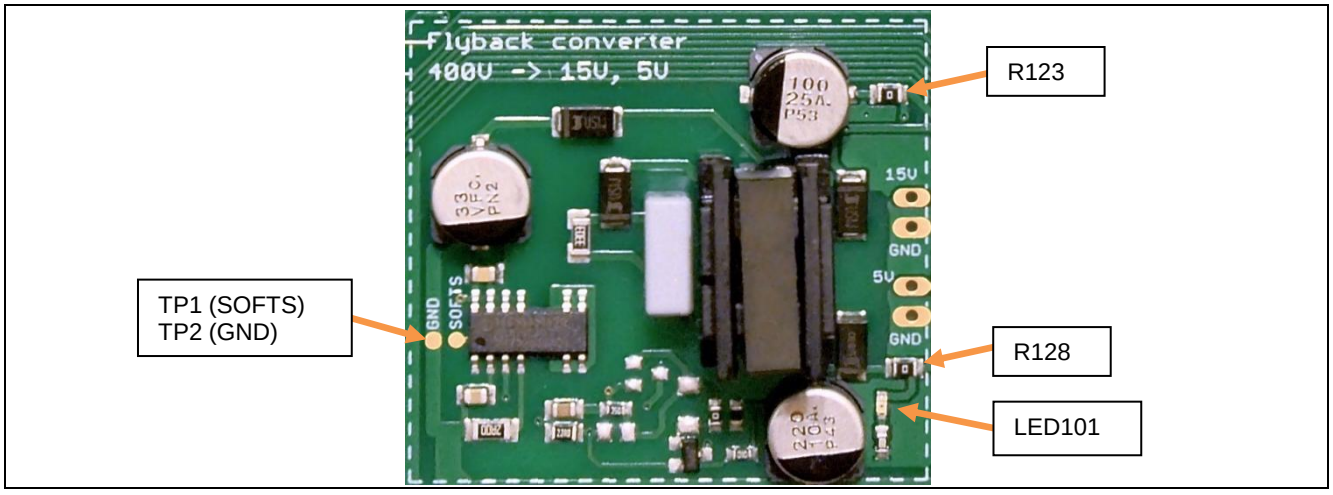


Figure 11 Restart of Control Power Supply via Testpads

The power status of VDD_5V is indicated by LED101 (see Figure 10).

2.2 3 Phase Inverter

The 3 phase power inverter is built by 6 IGBTs (IKD10N60R) and the gate driver IC (6EDL04I06NT). Each inverter leg has its own shunt in the low side path for phase current measurement. In addition the common DC-link current can be measured by its own shunt. See Figure 12 and Figure 13 for details.

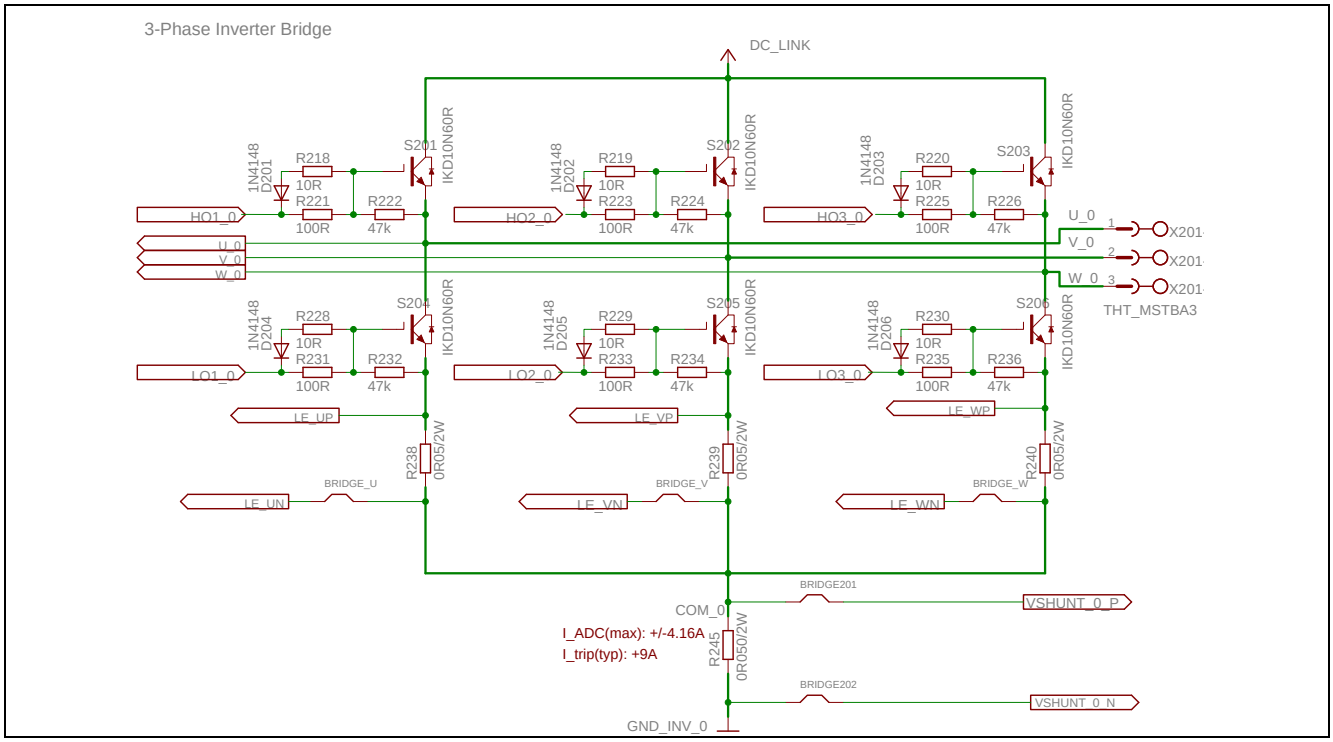


Figure 12 Power Inverter – IGBT

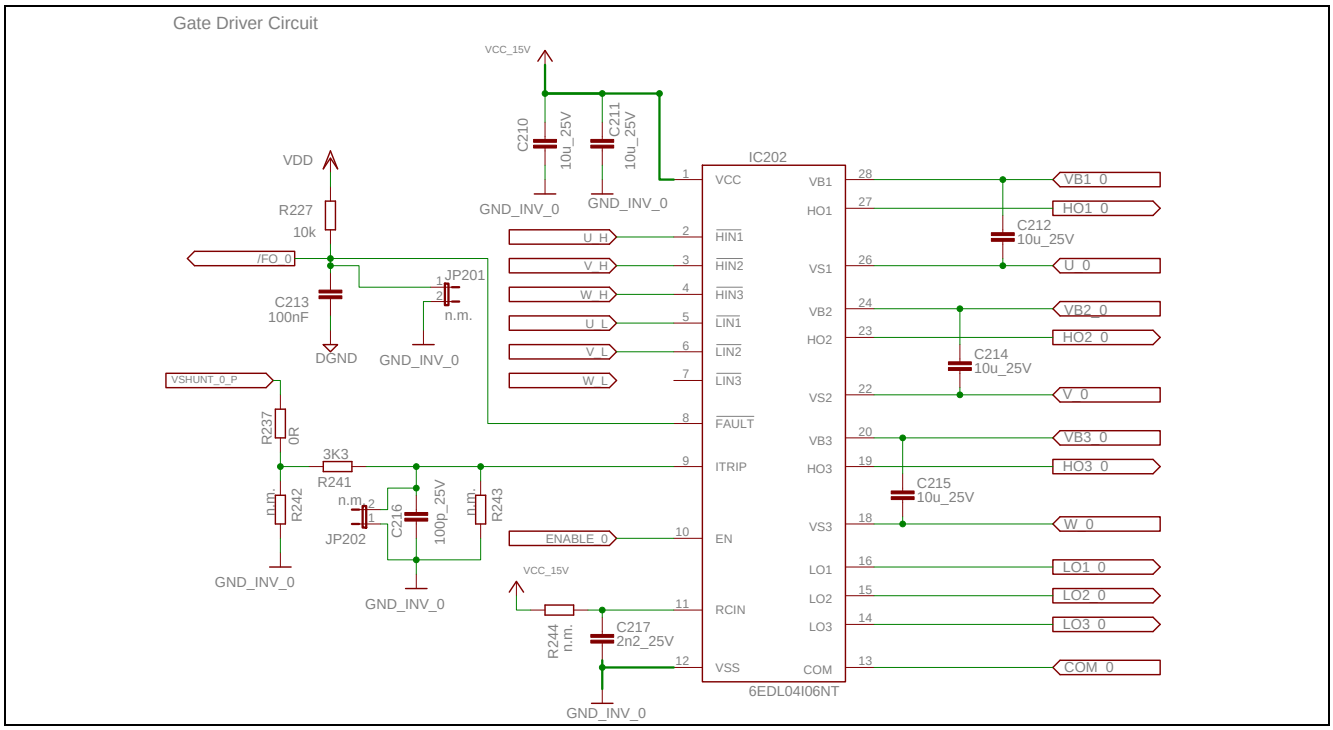


Figure 13 Power Inverter – Gate Driver

All shunt signals are amplified by operational amplifiers. The gain and offset of all amplifiers is adjusted to the same value. The offset is buffered by another operational amplifier. See Figure 14 and Figure 15 for details.

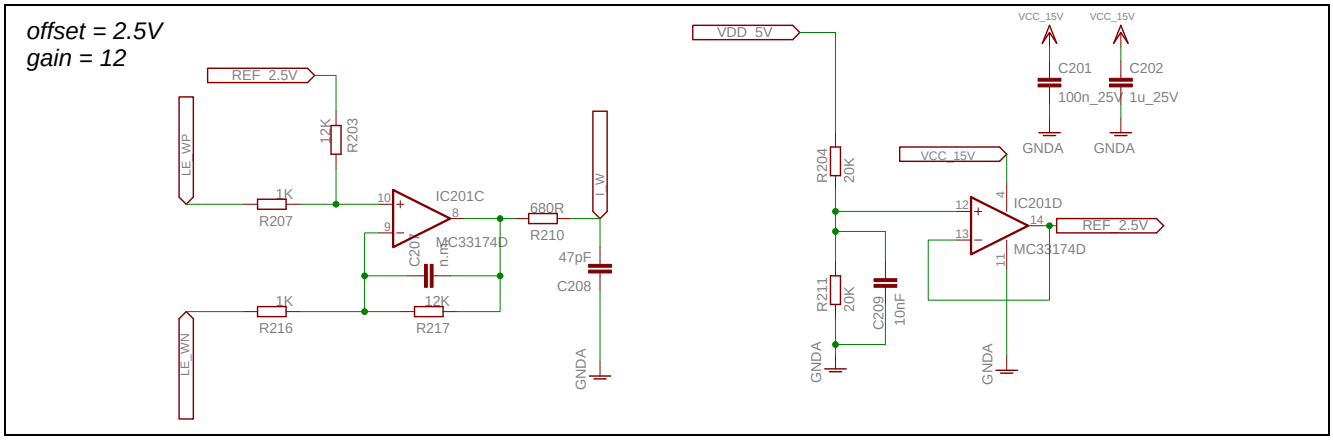


Figure 14 Phase Current Sensing and Reference Voltage Buffer (e.g. Phase W)

$$\text{offset} = \text{REF\_2.5V} = \frac{\text{R211}}{\text{R211} + \text{R204}} \cdot \text{VDD\_5V}$$

$$\text{gain} = \frac{\text{R217}}{\text{R216}} \text{ under the condition that } \frac{\text{R203}}{\text{R207}} = \frac{\text{R217}}{\text{R216}}$$

$$\text{Vout} = \text{offset} + \text{gain} \cdot \Delta\text{Vshunt} = \text{offset} - \text{gain} \cdot \text{R240} \cdot \text{I}_{\text{Phase\_W}}$$

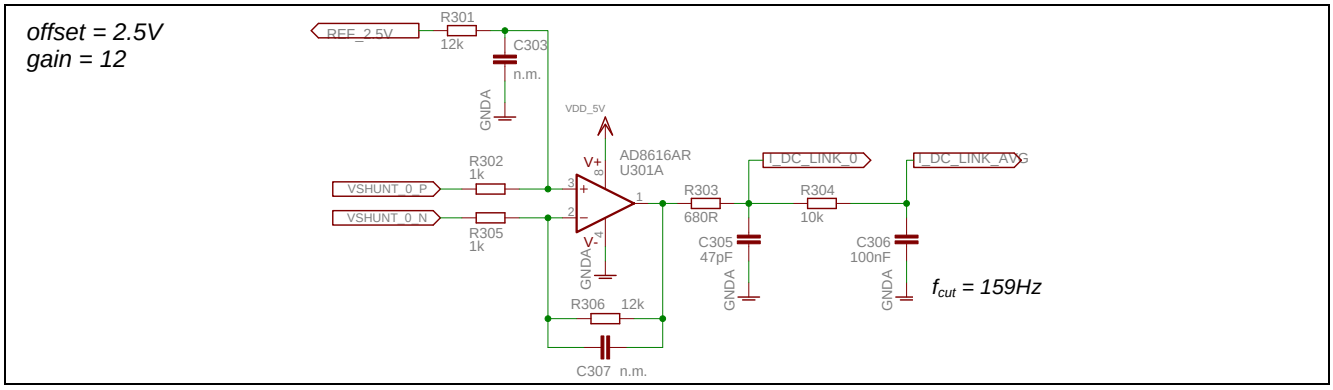


Figure 15 DC-Link Current Sensing

The gains are adjusted to measure a maximum current of 4.16A and to trigger the over voltage protection of the gate driver at 9A. There are testpoints for monitoring the itrip voltage as well as the protection output signal (/FO).

The following diagram (Figure 16) shows the timing of the gate driver for high side and low side IGBTs.

The dead time (t_{DT+} for rising and t_{DT-} for falling output signals) is the time which is required between deactivation e.g. of the high side IGBT (U_H: low to high, active to passive level, respectively) and the activation of the low side IGBT (U_L: high to low, passive to active level, respectively).

The driver delay (t_{DD+} for rising and t_{DD-} for falling output signals) is the delay time of the driver for changing the output signal from low to high after the activation of the respective IGBT driver input (high side for high output and low side for low output signal).

In the diagram (Figure 16) the delay time defined by the driver itself is shown as t_{DxOFF} and t_{DxON} (with x=H for high side and x=L for low side) and can be measured between microcontroller output signal and IGBT gate signal.

The total output delay time taken from the microcontroller signal edge until the inverter output level has changed is described with t_{OUT+} for low to high transition and t_{OUT-} for high to low transition.

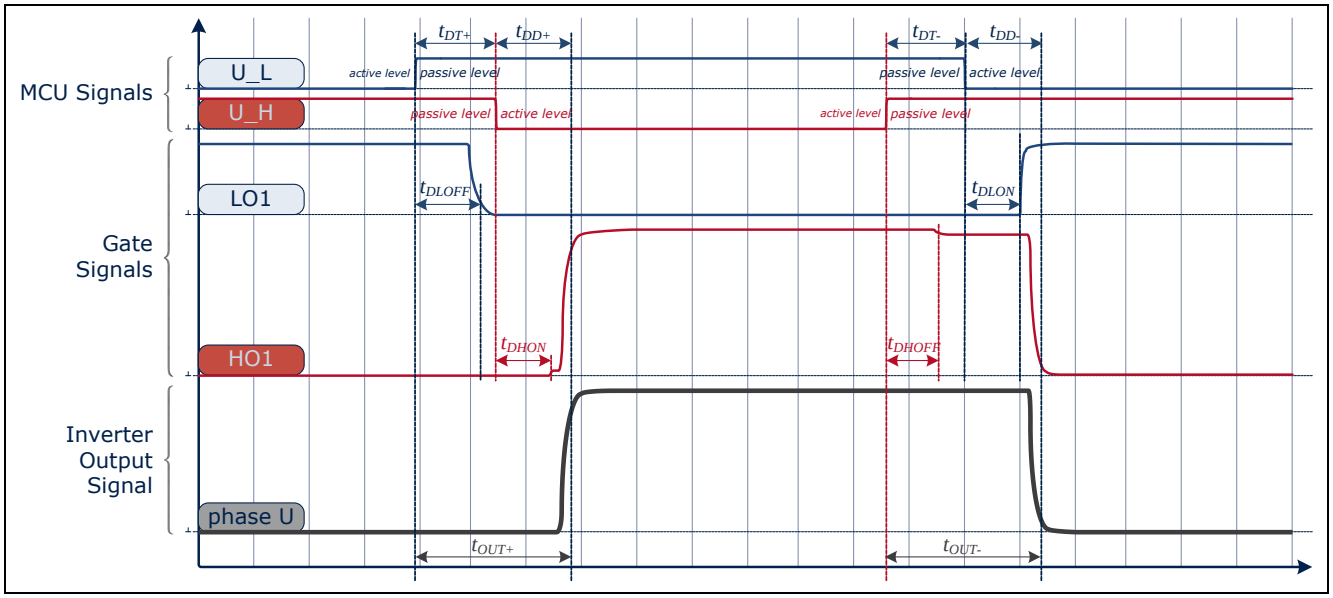


Figure 16 Inverter Timing Diagram

Please refer to Table 2 for typical values of the “3 Phase Power Inverter 750W V1.1” which have been measured under room temperature.

Table 2 Typical Inverter Timing Parameters

	Rising Output Signal		**Falling Output Signal**	
Dead Time	t_{DT+}	750ns	t_{DT-}	750ns
Driver Delay	t_{DD+}	800ns	t_{DD-}	800ns
Total Output Delay	t_{OUT+}	1.550µs	t_{OUT+}	1.550µs
	High Side		**Low Side**	
IGBT Drive ON delay	t_{DHON}	550ns	t_{DLON}	550ns
IGBT Driver OFF delay	t_{DHOFF}	550ns	t_{DLOFF}	650ns

The gate driver enable signal is inverted in order to provide active low behaviour. LED 301 indicates an active gate driver. The power inverter outputs can be monitored at signals BEMF_U, BEMF_V and BEMF_W with a ratio of 417.5V : 5V. Please refer to Figure 17 for details.

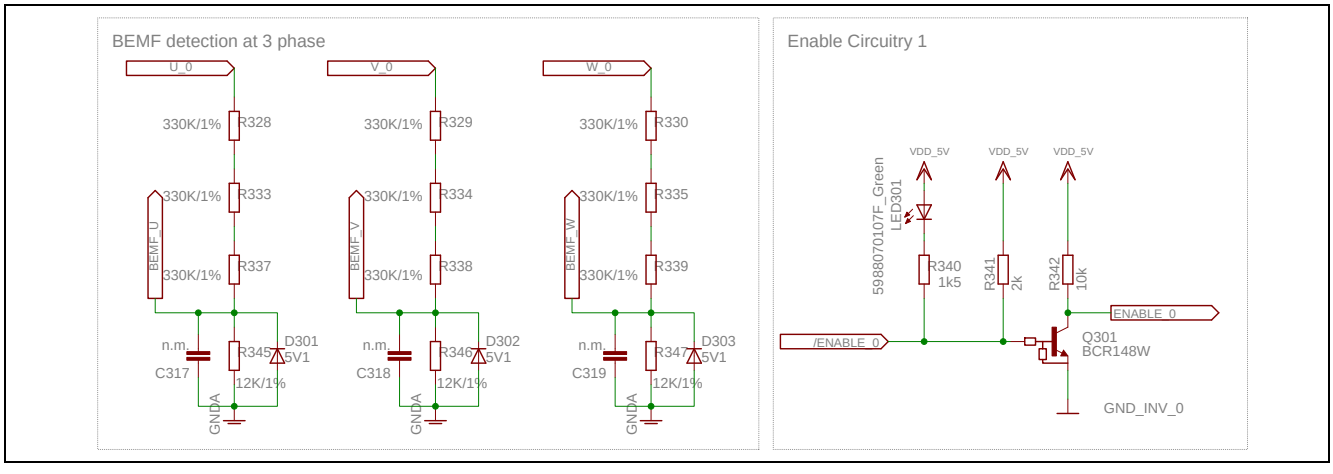
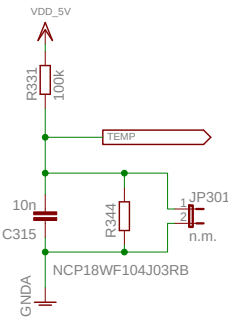


Figure 17 Output Voltage (BEMF) Signal Dividers and Inverting Gate Driver Enable Circuitry

A tempertaure sensor (R331, NTC thermistor) is placed close to the IGBTs of the inverter bridge in order to allow thermal protection by software. In addition, an external temperature sensor can be connected at JP301. Please refer to Figure 18 for details about the selected component (muRata NCP18WF104J03RB).



B-Constant	Calculated between two specified ambient temperatures by next formula. T and T0 is absolute temperature (K). $B = \frac{\ell n (R/R_0)}{1/T - 1/T_0}$

Part Number	Resistance (25°C) (ohm)	B-Constant (25-50°C) (K)	B-Constant (25-80°C) (Reference Value) (K)	B-Constant (25-85°C) (Reference Value) (K)	B-Constant (25-100°C) (Reference Value) (K)	Permissive Operating Current (25°C) (mA)	Rated Electric Power (25°C) (mW)	Typical Dissipation Constant (25°C) (mW/°C)
NCP18WF104□03RB	100k	4250 ±2%	4303	4311	4334	0.10	100	1

□ is filled with resistance tolerance codes (E: ±3%, J: ±5%).

Figure 18 Temperature Sensor Circuitry and Thermistor Parameter

2.3 Drive Card Connector

The power inverter board of KIT_XMC750WATT_AK_V1 provides a drive card connector with all the signals required to control the power inverter. Next to the PWM input signals of the gate driver as well as the sense signals for current measurement, there are the power supply pins for the 5V power domain.

Figure 19 shows the signal assignment fo the drive card connector together with the pin assignment of the drive cards for XMC1300 and XMC4400. The pin and peripheral assignment can also be found in the following table.

Please note that the numbering of the power board connector at the drive card is inversed to the numbering of the drive card connector at the power board.

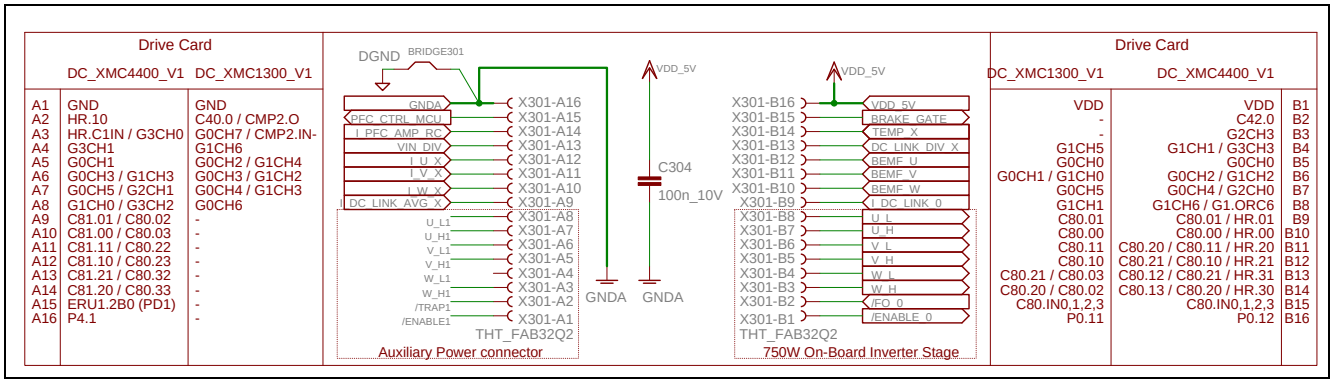


Figure 19 Drive Card Connector

Table 3 Drive Card Connector

Male MAB32B2	X301 FAB32Q2	Function	Signal of Power Inverter	Port XMC1300	Port XMC4400
A1	A16	GND	GNDA / DGND	VSS, VSSP	VSS
A2	A15	PFC Gate	PFC_CTRL_MCU	P0.5	P1.3 & P0.8
A3	A14	I_{PFC}	I_PFC_AMP_RC	P2.2	P15.8 & P0.0
A4	A13	V_{PFC}	VIN_DIV	P2.4	P15.9
A5	A12	V_{BEMF_U} / I_U (2)	I_U_X	P2.9	P14.1
A6	A11	V_{BEMF_V} / I_V (2)	I_V_X	P2.10	P14.15

A7	A10	V_{BEMF_W} / I_W (2)	I_W_X	P2.11	P14.5
A8	A9	I_AVG / I_{DClink} (2)	I_DC_LINK_AVG_X	P2.1	P14.8
A9	A8	U1_L	U_L1	-	P1.12 & P0.10
A10	A7	U1_H	U_H1	-	P1.15 & P2.7
A11	A6	V1_L	V_L1	-	P1.11 & P2.9
A12	A5	V1_H	V_H1	-	P1.5
A13	A4	W1_L	W_L1	-	P1.10 & P2.8
A14	A3	W1_H	W_H1	-	P1.4
A15	A2	CTRAP1	/TRAP1	-	P1.2
A16	A1	ENPOW1	/ENABLE1	-	P4.1
B1	B16	VCC 5V	VDD_5V	VDD, VDDP	VDD
B2	B15	Brake Gate	BRAKE_GATE	-	P3.6
B3	B14	Brake temp	TEMP_X	-	P15.3
B4	B13	V_{DClink}	DC_LINK_DIV_X	P2.3	P14.9
B5	B12	V_{BEMF_U} / I_U (1)	BEMF_U	P2.6	P14.0
B6	B11	V_{BEMF_V} / I_V (1)	BEMF_V	P2.8	P14.2
B7	B10	V_{BEMF_W} / I_W (1)	BEMF_W	P2.0	P14.4
B8	B9	I_{DClink} (1)	I_DC_LINK_0	P2.7	P14.14
B9	B8	U0_L	U_L	P0.1	P0.2
B10	B7	U0_H	U_H	P0.0	P0.5
B11	B6	V0_L	V_L	P0.6	P0.1 & P0.3
B12	B5	V0_H	V_H	P0.7	P0.4 & P2.14
B13	B4	W0_L	W_L	P0.9 & P0.3	P0.11 & P0.9
B14	B3	W0_H	W_H	P0.8 & P0.2	P0.6 & P2.6
B15	B2	CTRAP0	/FO_0	P0.12	P0.7
B16	B1	ENPOW0	/ENABLE_0	P0.11	P0.12

Attention: The drive card connector provides the power supply for the power GND supply domain. Hence it may carry hazzardous voltages.

2.4 Auxiliary Power Board Connector

A second inverter card can be connected to the auxiliary power board connector. There are all necessary signals and power supplies available. Please refer to Figure 20 for details.

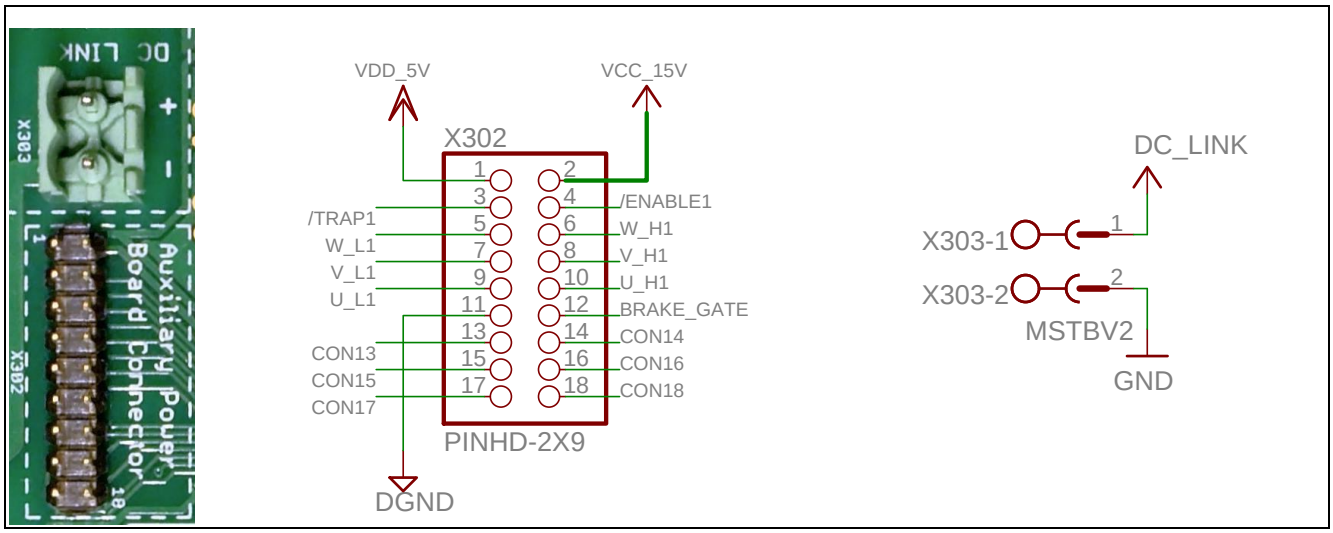


Figure 20 Auxiliary Power Board Connector

This connector is considered as an optional extension and the analog signals are shared netween the on-board power inverter and the auxiliary connector. The desired signal can be chosen by 0R resistors close to the Drive Card connector. Figure 21 and the following table give details about the optional signal selection.

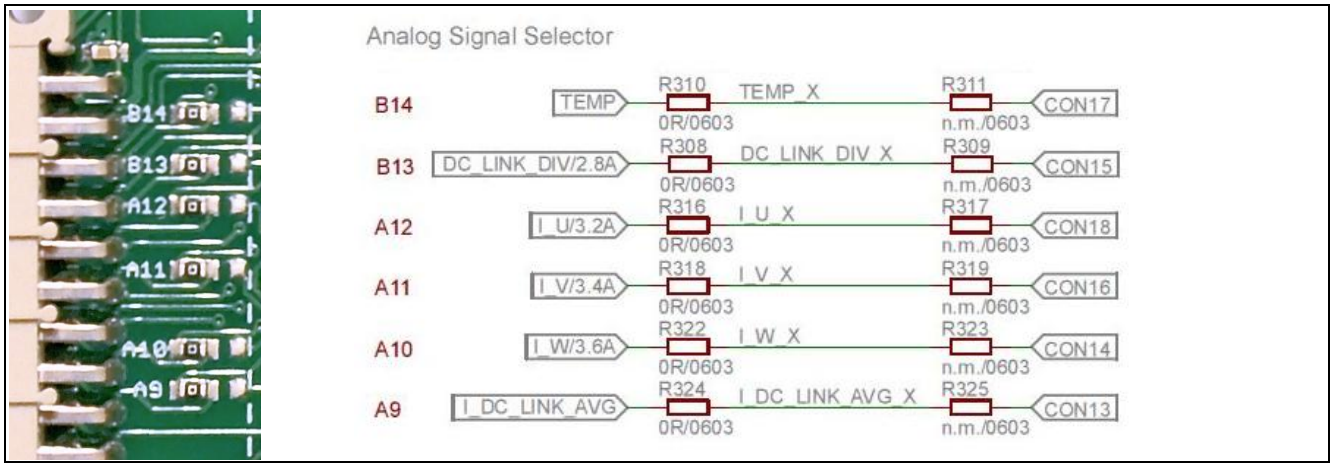


Figure 21 Analog Signal Selector

Table 4 Auxiliary Power Board Connector

X302 Auxiliary Power Board Connector	X301 Drive Card Connector	Signal at Drive Card Connector	Signal of Power Inverter	Optional Signal X302
X302-1	B16	VDD_5V	VDD_5V	VDD_5V
X302-2	-	-	VCC_15V	VCC_15V
X302-3	A2	/TRAP1	-	/TRAP1
X302-4	A1	/ENABLE1	-	/ENABLE1
X302-5	A4	W_L1	-	W_L1
X302-6	A3	W_H1	-	W_H1
X302-7	A6	V_L1	-	V_L1
X302-8	A5	V_H1	-	V_H1
X302-9	A8	U_L1	-	U_L1
X302-10	A7	U_H1	-	U_H1
X302-11	A16	GND	DGND	DGND
X302-12	B15	BRAKE GATE	-	BRAKE GATE
X302-13	(A9)	I_DC_LINK_AVG_X	I_DC_LINK_AVG	CON13
X302-14	(A10)	I_W_X	I_W	CON14
X302-15	(B13)	DC_LINK_DIV_X	DC_LINK_DIV	CON15
X302-16	(A11)	I_V_X	I_V	CON16
X302-17	(B14)	TEMP_X	TEMP	CON17
X302-18	(A12)	I_U_X	I_U	CON18

3 Production Data

3.1 Schematics

This chapter contains the schematics for the 3 phase power inverter 750W V1.1 (2013/45).

- Line Filter, PFC, DC-Link 400V, Power Supply 15V/5V
- Gate Driver, Power Bridge (IGBT), Phase Current Shunt Amplifier
- Single Shunt Amplifier, PFC Amplifier, PFC Overload Protection, Drive Card and Auxiliary Power Connector

The board has been designed with Eagle V5.7. The full PCB design data of this board can also be downloaded from www.infineon.com/xmc-dev.

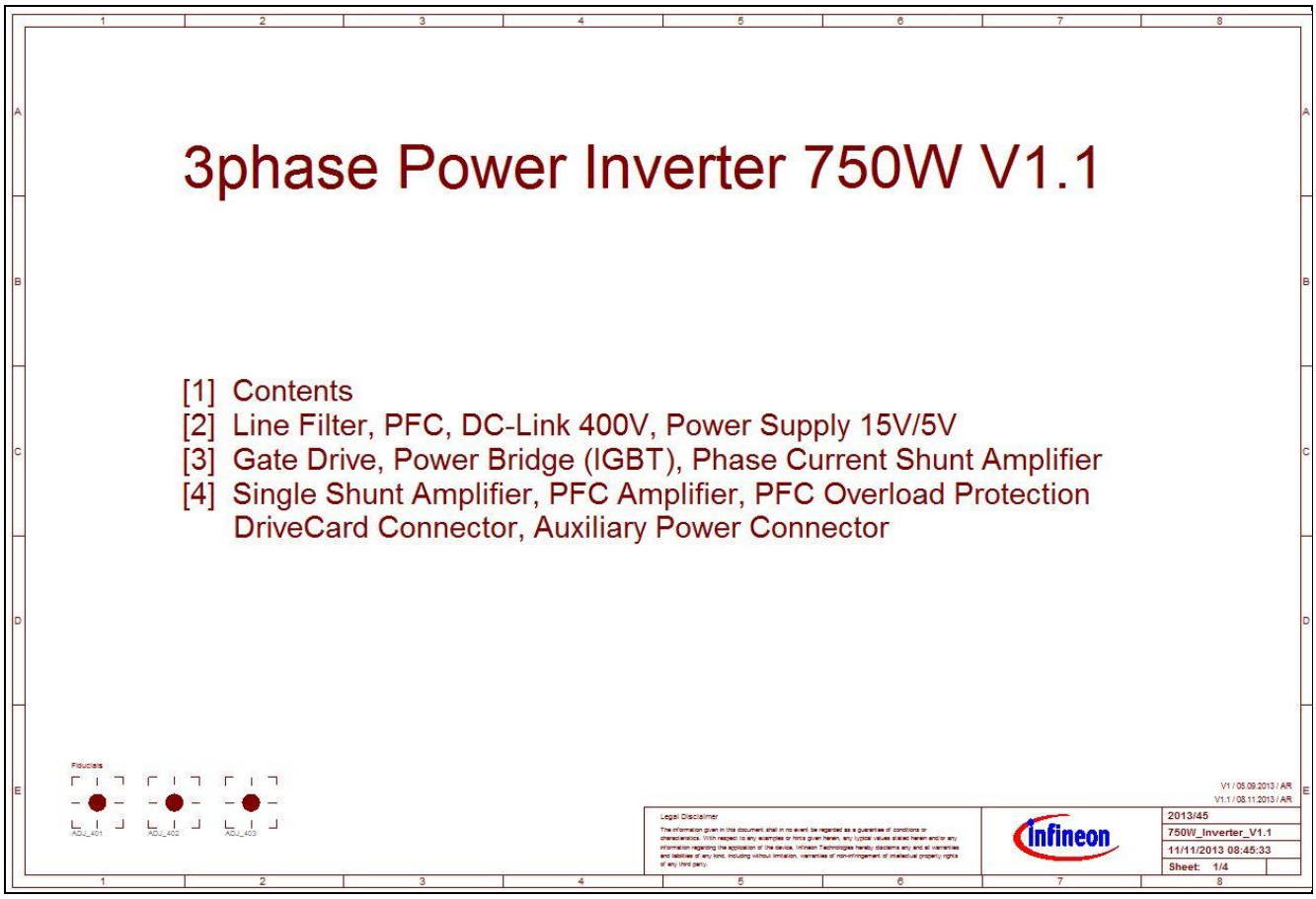

3phase Power Inverter 750W V1.1
[1] Contents
[2] Line Filter, PFC, DC-Link 400V, Power Supply 15V/5V
[3] Gate Drive, Power Bridge (IGBT), Phase Current Shunt Amplifier
[4] Single Shunt Amplifier, PFC Amplifier, PFC Overload Protection
DriveCard Connector, Auxiliary Power Connector
Fiducials
Legal Disclaimer
2013/45
750W_Inverter_V1.1
11/11/2013 08:45:33
Sheet: 1/4

Figure 22 Schematics: Title Page (V1.1 – 2013/45)

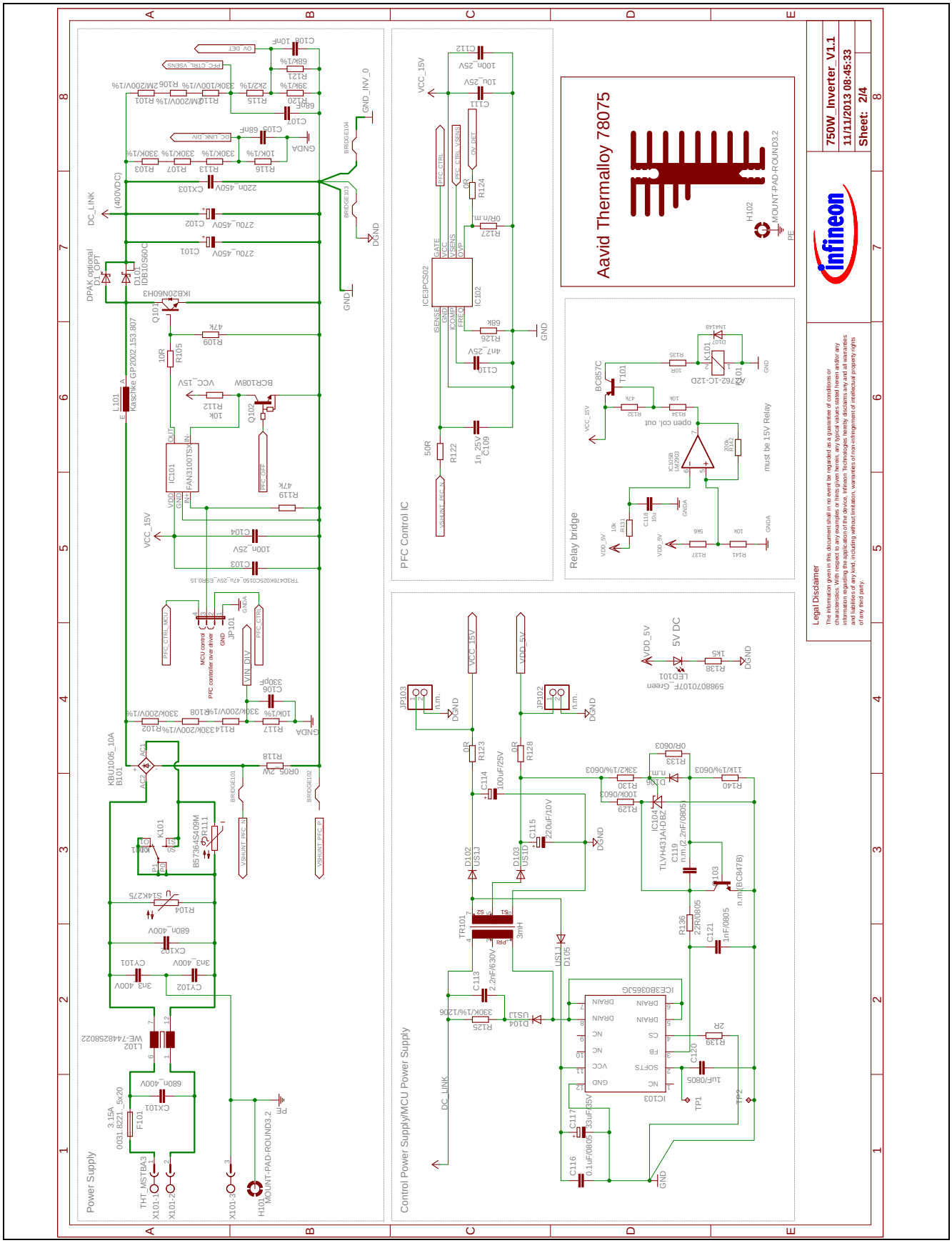


Figure 23 Line Filter, PFC, DC-Link 400V, Power Supply 15V/5V

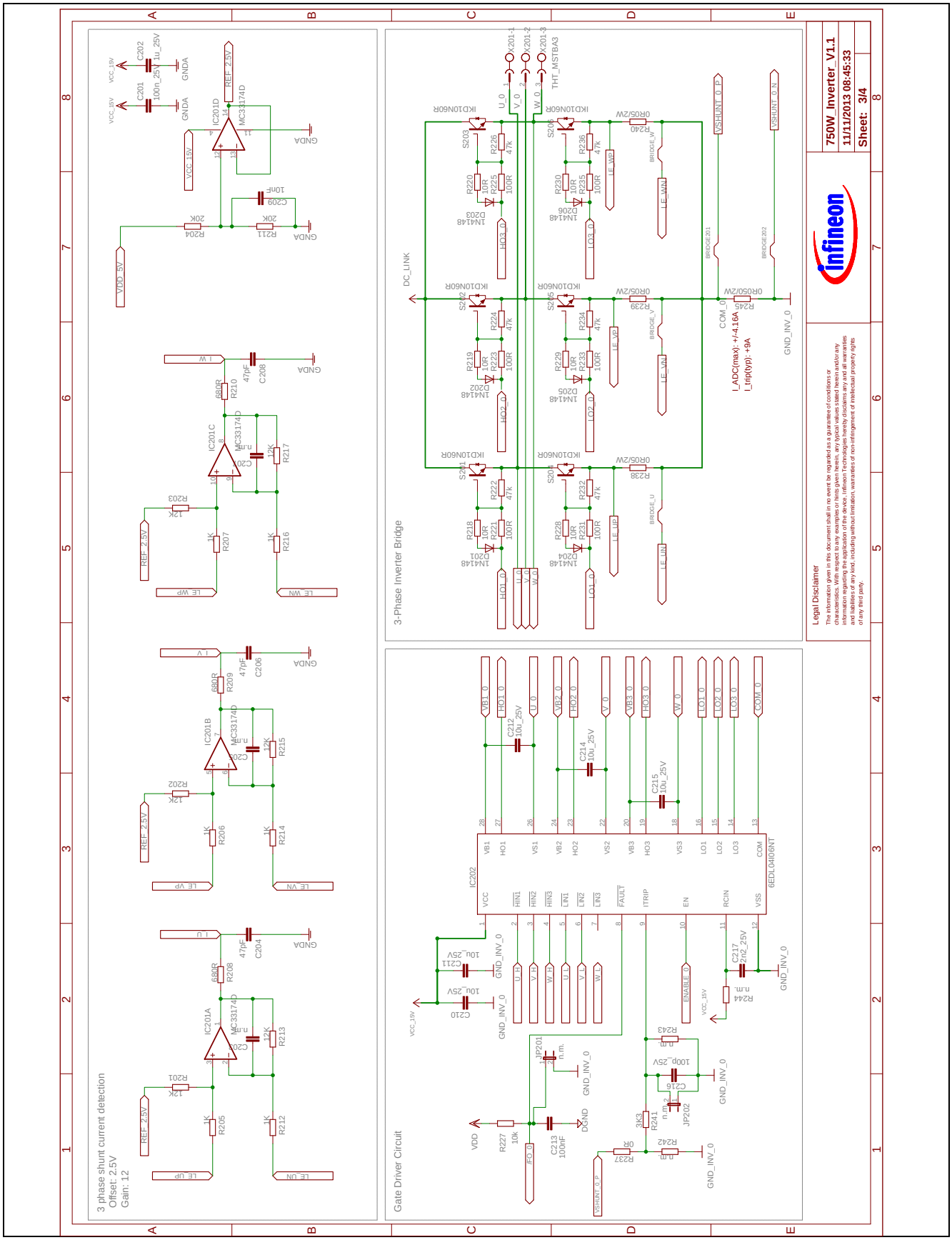


Figure 24 Gate Driver, Power Bridge (IGBT), Phase Current Shunt Amplifier

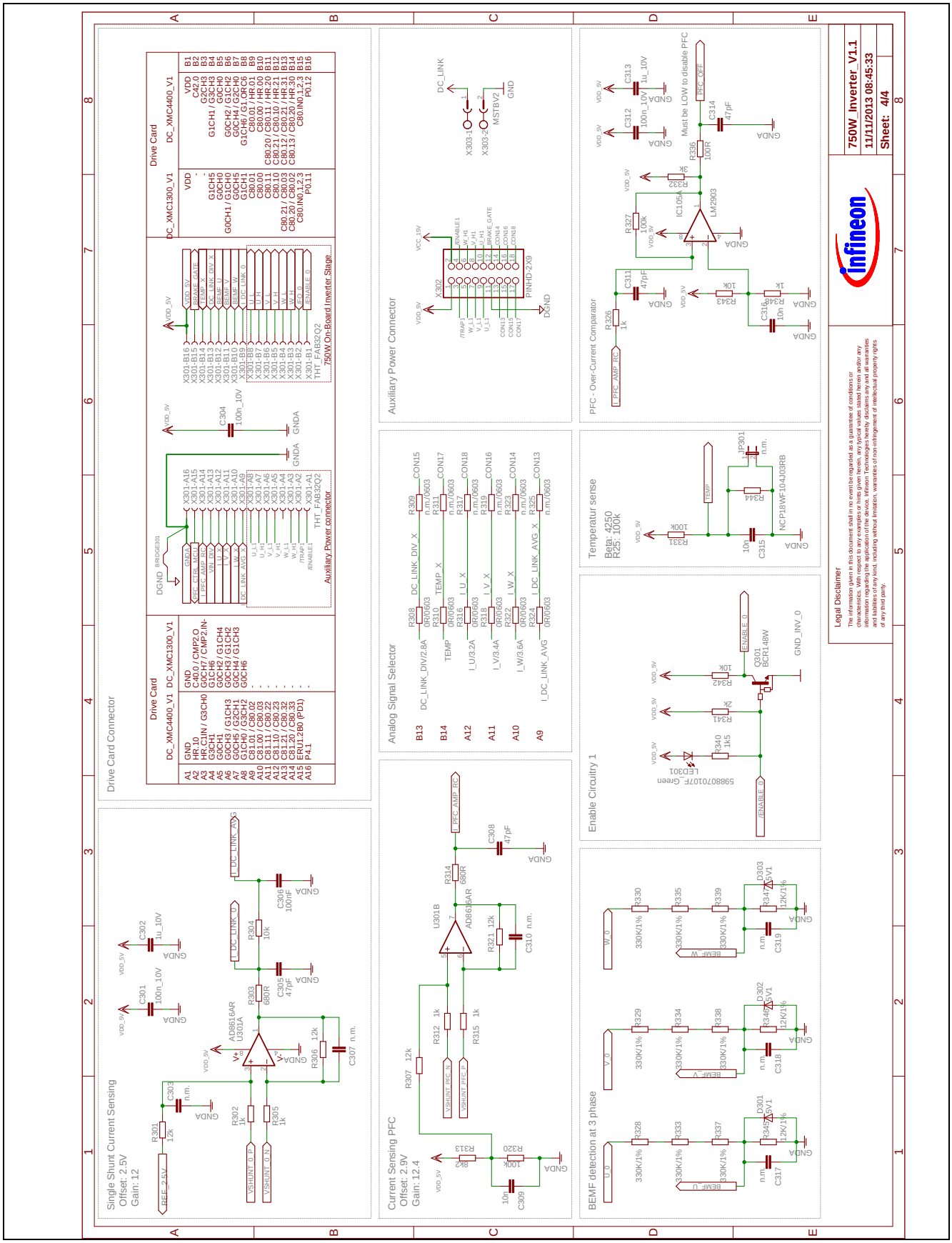


Figure 25 Single Shunt and PFC Amplifier, PFC Protection, Drive Card and Auxiliary Power Connector

3.2 Component Placement

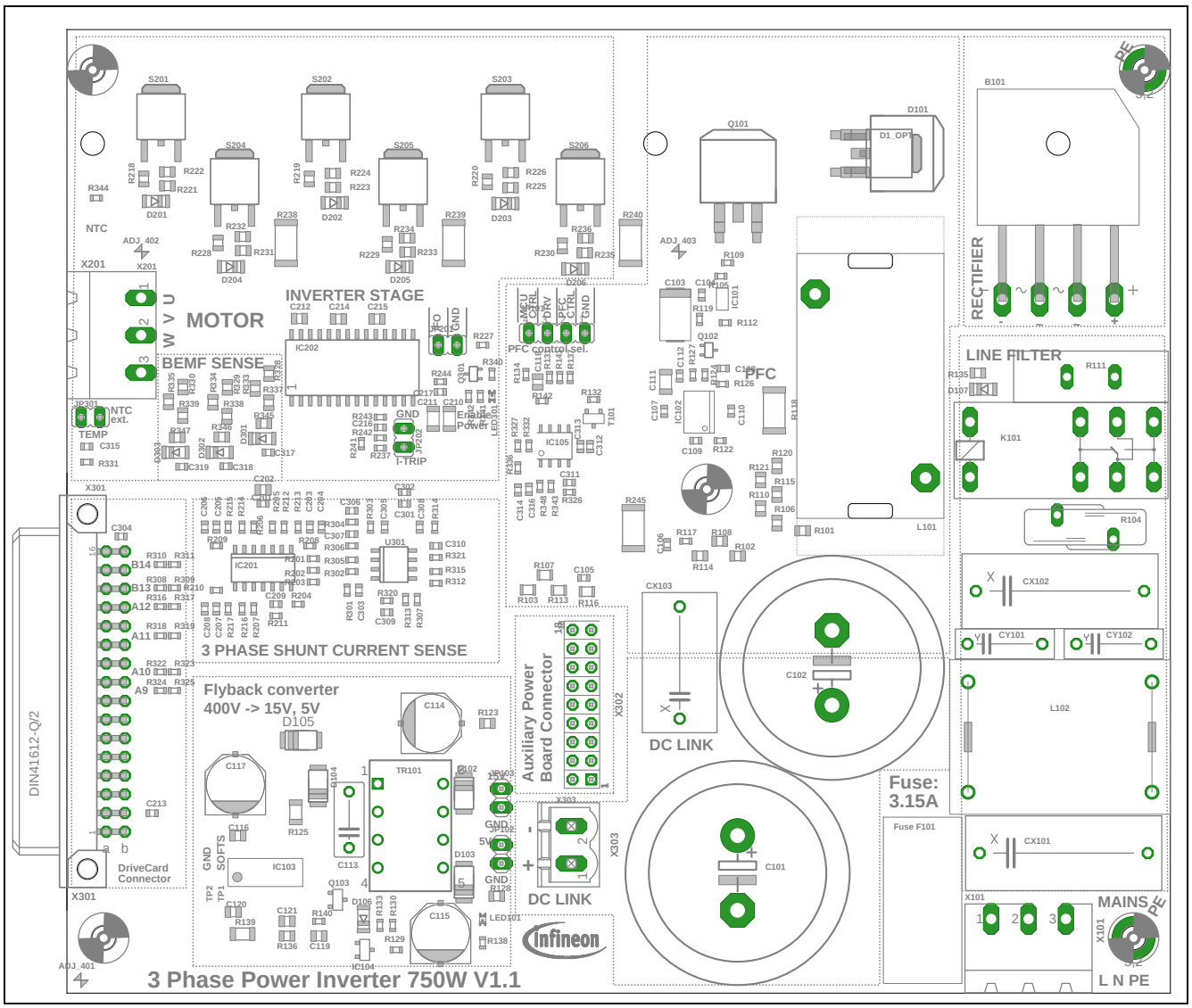


Figure 26 Component Placement

3.3 Board Dimensions and Mounting Hole Positions

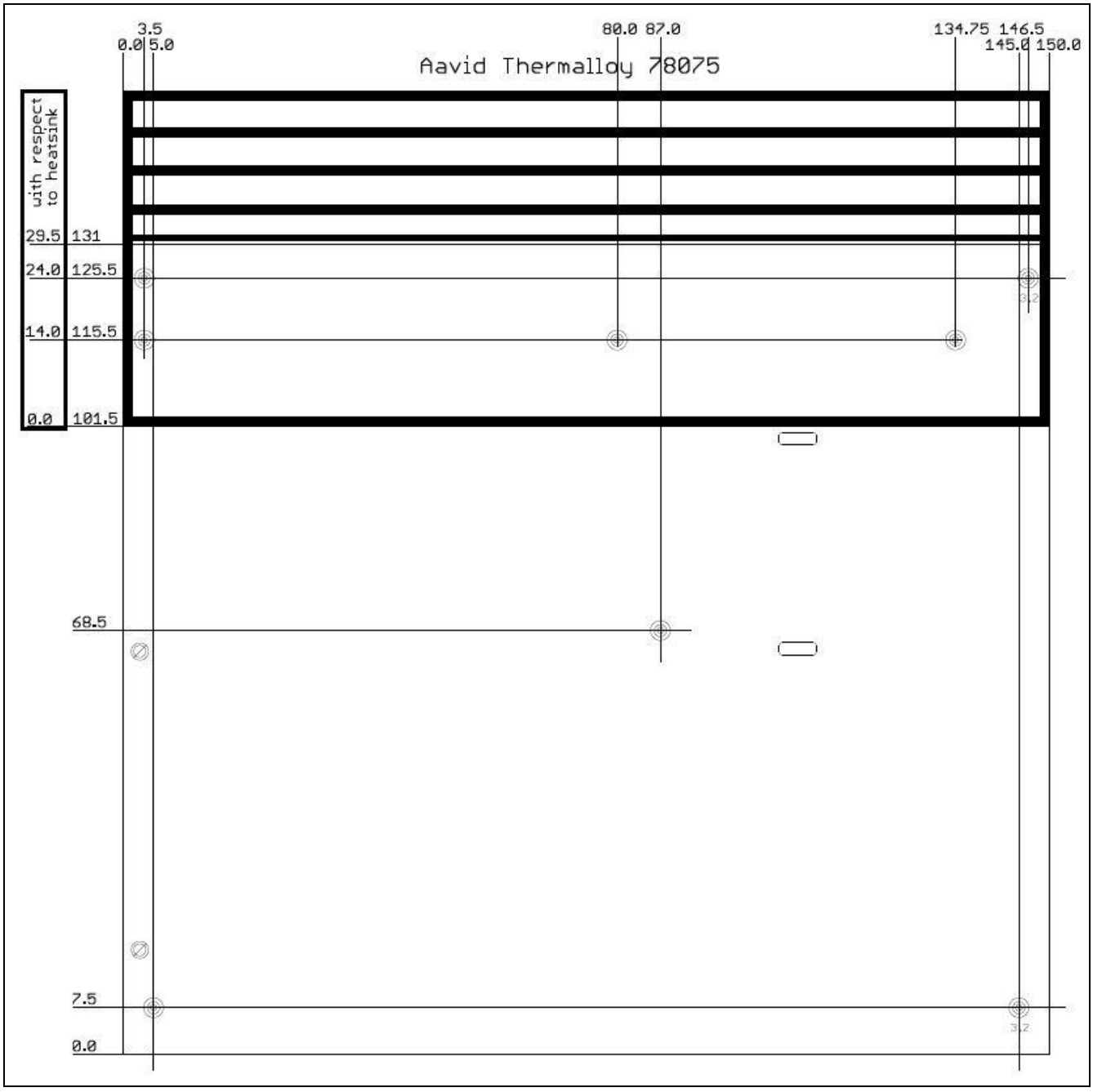


Figure 27 Board Dimensions and Mounting Hole Positions

3.4 Winding Rules for Transformer TR101

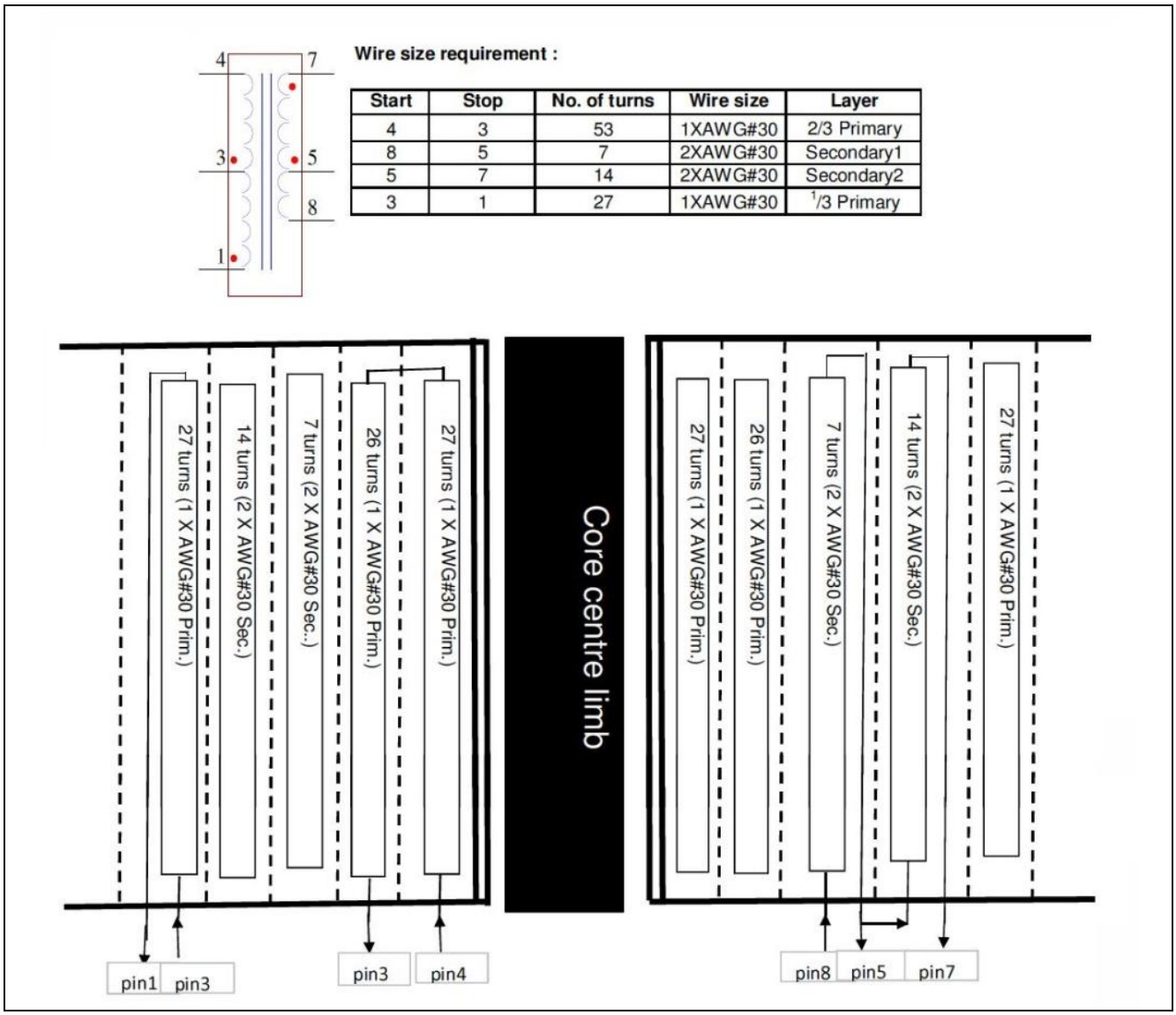

4
7
3
5
8
1
Wire size requirement :
Start | Stop | No. of turns | Wire size | Layer
4 | 3 | 53 | 1XAWG#30 | 2/3 Primary
8 | 5 | 7 | 2XAWG#30 | Secondary1
5 | 7 | 14 | 2XAWG#30 | Secondary2
3 | 1 | 27 | 1XAWG#30 | 1/3 Primary
27 turns (1 X AWG#30 Prim.)
14 turns (2 X AWG#30 Sec.)
7 turns (2 X AWG#30 Sec.)
26 turns (1 X AWG#30 Prim.)
27 turns (1 X AWG#30 Prim.)
Core centre limb
27 turns (1 X AWG#30 Prim.)
26 turns (1 X AWG#30 Prim.)
7 turns (2 X AWG#30 Sec.)
14 turns (2 X AWG#30 Sec.)
27 turns (1 X AWG#30 Prim.)
pin1
pin3
pin3
pin4
pin8
pin5
pin7

Figure 28 Winding Rules for Transformer TR101

3.5 Bill of Material (BOM)

Table 5 BOM of KIT_XMC750WATT_AK_V1 Board

Pos. No.	Qty	Value	Device	Reference Des.
1	1	KBU1005_10A	GBU4GBU4H	B101
2	2	270u_450V	CPOL-EUE10-30	C101, C102
3	1	TR3D476K025C0150_47u_25V_ESR0.15	C_EU_CASE_CCASE_D	C103
4	2	100n_25V	C_EU_CASE_C0603	C104, C112
5	2	68nF	C_EU_CASE_C0603	C105, C107
6	1	330pF	C_EU_CASE_C0603	C106
7	1	10nF	C_EU_CASE_C0603	C108
8	1	1n_25V	C_EU_CASE_C0603	C109
9	1	4n7_25V	C_EU_CASE_C0603	C110
10	3	10u_25V	C_EU_CASE_C1206	C111, C210, C211
11	1	2.2nF/630V	C-EU075-042X103	C113
12	1	100uF/25V	CPOL-EUE	C114
13	1	220uF/10V	CPOL-EUE	C115
14	1	0.1uF/0805	C-EUC0805	C116
15	1	33uF/35V	CPOL-EUE	C117
16	1	10u	C_EU_CASE_C0805	C118
17	1	1uF/0805	C-EUC0805	C120
18	1	1nF/0805	C-EUC0805	C121
19	1	100n_25V	C-EUC0603	C201
20	1	1u_25V	C-EUC0805	C202
21	7	47pF	C-EUC0603	C204, C206, C208, C305, C308, C311, C314
22	1	10nF	C-EUC0603	C209
23	3	10u_25V	C_EU_CASE_C0805	C212, C214, C215
24	1	100nF	C_EU_CASE_C0603	C213
25	1	100p_25V	C_EU_CASE_C0603	C216
26	1	2n2_25V	C_EU_CASE_C0603	C217
27	3	100n_10V	C-EUC0603	C301, C304, C312
28	2	1u_10V	C-EUC0603	C302, C313
29	1	100nF	C-EUC0603	C306
30	3	10n	C-EUC0603	C309, C315, C316
31	2	680n_400V	CXXC22B10	CX101, CX102
32	1	220n_450V	CXXC15B10	CX103
33	2	3n3_400V	CYYC10B4	CY101, CY102
34	1	IDB10S60C	IDT08S60C	D101
35	3	US1J	DIODE-DO-214AC	D102, D104, D105
36	1	US1D	DIODE-DO-214AC	D103
37	7	1N4148	DIODE-SOD80C	D107, D201, D202, D203, D204, D205, D206
38	3	5V1	DIODE-MINIMELF	D301, D302, D303
39	1	Thermalloy	78075	HEATSINK101
40	1	FAN3100TSX	FAN3100	IC101
41	1	ICE3PCS02	ICE3PCS02	IC102

42	1	ICE3B0365JG	ICE3B0365JG	IC103
43	1	TLVH431AI-DBZ	TLV431A-DBZ	IC104
44	1	LM2903	LM2903	IC105
45	1	MC33174D	LM324D	IC201
46	1	6EDL04I06NT	6ED003L06-F	IC202
47	1	AZ762-1C-12D	G2RE	K101
48	1	Kaschke GP2002.153.807	KLL_GP2002.1	L101
49	1	WE-7448258022	WE-CMB_XL	L102
50	2	5988070107F_Green	LEDCHIPLED_0603	LED101, LED301
51	1	IKB20N60H3	IKB30N60H3	Q101
52	1	BCR108W	BCR108W	Q102
53	1	BCR148W	BCR108W	Q301
54	2	2M/200V/1%	R-EU_R0805	R101, R106
55	3	330k/200V/1%	R-EU_R0805	R102, R108, R114
56	3	330K/1%	R-EU_M0805	R103, R107, R113
57	1	S14K275	S14K275	R104
58	1	10R	R-EU_R0603	R105
59	3	47k	R-EU_R0603	R109, R119, R132
60	1	330k/100V/1%	R-EU_R0805	R110
61	1	B57364S409M	NTC-B57364	R111
62	8	10k	R-EU_R0603	R112, R131, R134, R141, R227, R304, R342, R343
63	1	2k2/1%	R-EU_R0805	R115
64	1	10K/1%	R-EU_M0805	R116
65	1	10k/1%	R-EU_R0603	R117
66	1	0R05_2W	R-EU_R2512	R118
67	1	39k/1%	R-EU_R0805	R120
68	1	68k/1%	R-EU_R0805	R121
69	1	50R	R-EU_R0603	R122
70	2	0R	R-EU_R0805	R123, R128
71	2	0R	R-EU_R0603	R124, R237
72	1	330K/1%/1206	R-EU_R1206	R125
73	1	68k	R-EU_R0603	R126
74	1	100k/0603	R-EU_R0603	R129
75	1	33k2/1%/0603	R-EU_R0603	R130
76	7	0R/0603	R-EU_R0603	R133, R308, R310, R316, R318, R322, R324
77	7	10R	R-EU_R0805	R135, R218, R219, R220, R228, R229, R230
78	1	22R/0805	R-EU_R0805	R136
79	1	5k6	R-EU_R0603	R137
80	2	1k5	R-EU_R0603	R138, R340
81	1	2R	R-EU_R1206	R139
82	1	11k/1%/0603	R-EU_R0603	R140
83	1	200k	R-EU_R0603	R142
84	6	12K	R-EU_R0603	R201, R202, R203, R213, R215, R217
85	2	20K	R-EU_R0603	R204, R211

86	6	1K	R-EU_R0603	R205, R206, R207, R212, R214, R216
87	5	680R	R-EU_R0603	R208, R209, R210, R303, R314
88	6	100R	R-EU_R0805	R221, R223, R225, R231, R233, R235
89	6	47k	R-EU_R0805	R222, R224, R226, R232, R234, R236
90	3	0R05/2W	R-EU_R2512	R238, R239, R240
91	1	3K3	R-EU_R0603	R241
92	1	0R050/2W	R-EU_R2512	R245
93	4	12k	R-EU_R0603	R301, R306, R307, R321
94	6	1k	R-EU_R0603	R302, R305, R312, R315, R326, R348
95	1	8k2	R-EU_R0603	R313
96	3	100k	R-EU_R0603	R320, R327, R331
97	9	330K/1%	R-EU_R0805	R328, R329, R330, R333, R334, R335, R337, R338, R339
98	1	3k	R-EU_R0603	R332
99	1	100R	R-EU_R0603	R336
100	1	2k	R-EU_R0603	R341
101	1	NCP18WF104J03RB	R-EU_R0603	R344
102	3	12K/1%	R-EU_R0805	R345, R346, R347
103	6	IKD10N60R	IKD04N60R	S201, S202, S203, S204, S205, S206
104	1	BC857C	BC857A-PNP-SOT23-BEC	T101
105	1	3mH	EPCOS_E16V	TR101
106	1	AD8616AR	AD8616AR	U301
107	2	THT_MSTBA3	MSTBA3	X101, X201
108	1	THT_FAB32Q2	FAB32Q2	X301
109	1	PINHD-2X9	PINHD-2X9	X302
110	1	MSTBV2	MSTBV2	X303

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